GRC Human Research Program

Overview

GRC Human Research Program

Objectives

- Reduce spaceflight risks to humans, focused on the highest risks to crew health and performance during exploration missions
- Enable development of human spaceflight medical and human factors standards
- Develop and validate technologies that serve to reduce medical risks associated with human spaceflight

Goals

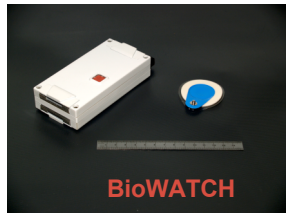
- Develop effective and reliable on-orbit exercise hardware requirements and validate candidate technologies
- Develop validated, efficient exercise prescriptions that minimize daily time needed for completion of exercise yet maximize performance for mission activities
- Develop medical requirements and technologies to ensure the safety and success of Exploration missions
- Hardware development, test and analysis including health care systems and procedures development
- Develop computational physiological and medical risk models for determination of effects of the space flight environment on humans

GRC Human Research Program

•Exercise Countermeasures

– Enhanced Zero Gravity Locomotion Simulator (eZLS) to study exercise protocols in micro and lunar gravity
– ISS Detailed Science Objective (DSO) for redesigned TVIS harness focusing on increased comfort and higher loading
– Critical Mission Task (CMT) Assessments
– Hardware Advanced Concepts for Lunar Sorties
– Lunar Analog Pilot Studies
– Standalone ZLS for UTMB Bedrest Facility

Enhanced Zero-g Locomotion Simulator

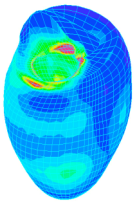


Prototype Harness (Cleveland Clinic)

• Physiological Simulations (Digital Astronaut)

– Quantify physiological changes due to spaceflight
– Guide research needed to reduce risk for human exploration

DA heart model



IMM: Fracture Risk

• Exploration Medical Capabilities

–Integrated Medical Model:
- Probability analysis to quantify medical risks
- Systems input for bone fracture, renal stone formation, and behavioral health

–Medical Fluids:
- Develop and flight test prototype hardware to generate water for IV pharmaceutical use
- Advanced medical fluids: contingency nutrition, injectable medications

–Clinical Hardware
- EVA applicable biomedical sensing systems (PUMA, BioWATCH, radiation)
- Integrated suite of sensors and reusable lab test equipment for monitoring astronauts and diagnosing medical conditions
- Re-usable MEMS biosensors for on-board medical laboratory diagnostics

PUMA Headgear

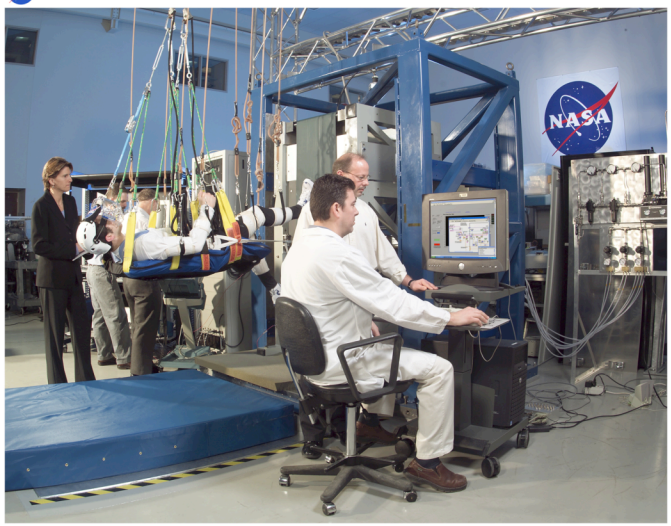
IV Fluids

Exercise Countermeasures at GRC

Exercise Countermeasures Laboratory

A New Ground - Based Capability for Space Exploration

C-2006-554



National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field

Mission Statement

The Exercise Countermeasures Laboratory (ECL) at NASA Glenn Research Center serves the NASA Exercise Countermeasures Project (ECP) and exercise community as a whole by providing the capability for simulating in-flight (0-g) and surface (fractional-g) exercise to advance the health and safety of the next generation of space explorers. The Exercise Countermeasures Laboratory features the Enhanced Zero-gravity Locomotion Simulator (eZLS), designed to allow development and validation of advanced exercise countermeasure devices, requirements, and exercise prescriptions for mitigating the detrimental physiological effects of long-duration spaceflight.

Exercise Countermeasures at GRC

Cleveland Clinic

CSM Harness DSO - Cleveland Clinic (CC)/GRC

Background

- CSM harness has obtained favorable subjective reviews from test subjects and astronauts running in eZLS

Purpose

- To further develop the CC harness to flight configuration, complete with built-in instrumentation to measure applied pressure and biometric parameters

Significance of Findings

- Data analysis from TVIS Harness Comfort Study conducted at GRC indicates the CC harness is favorable to the US harness currently on ISS
- Suggestions for design improvements have been collected and are being implemented in the new harness

Forward Work

- CC is working with Osprey to obtain harnesses for modification and instrumentation for the flight harness
- ZIN/GRC is researching materials and is generating models/drawings for the flight harness

NASA Astronaut tries out the CC Harness

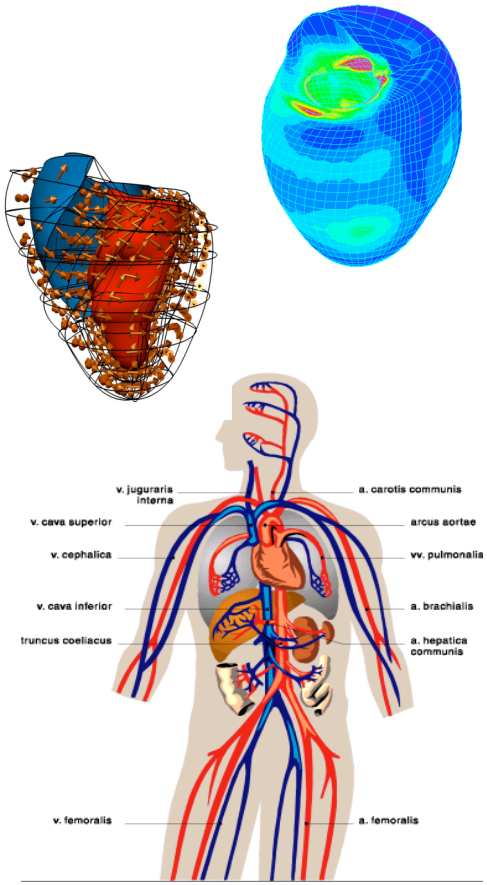
CSM Harness

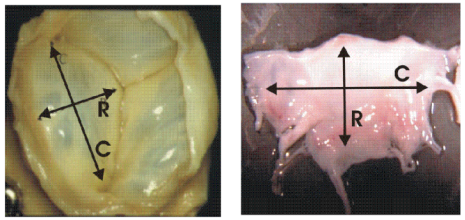
Digital Astronaut

Due to the limited number of opportunities to collect physiological data from astronauts during spaceflight and the limited size of the astronaut cohort, knowledge of space normal physiology and a detailed understanding of the effects of countermeasures in reduced gravity will not be available from clinical data alone. Furthermore, mission scenarios frequently ask physiology and health questions that must be answered quickly and with limited clinical data.

The goal of the Digital Astronaut Project is four fold. First, to develop the computational tools to quantify space normal physiology. Second, to assist HRP discipline researchers in eliminating knowledge gaps. Third, to provide input to HRP research investment decisions and fourth, to provide timely input to mission architecture and operations decisions in areas where clinical data are lacking.

The project will consist of an integrated simulation, known as the backbone, augmented as required by more detailed simulations. The need for more detailed simulations will be identified through the validation and verification processes of the components simulating various physiological systems. The backbone will be an adapted form of the BioSim physiological simulation that is available from the University of Mississippi Medical Center (UMMC). Project personnel will reside both at UMMC and GRC.





Exploration Medical Capability at GRC
Modeling Fracture Potential For Exploration Missions

courses.washington.edu/me598rc

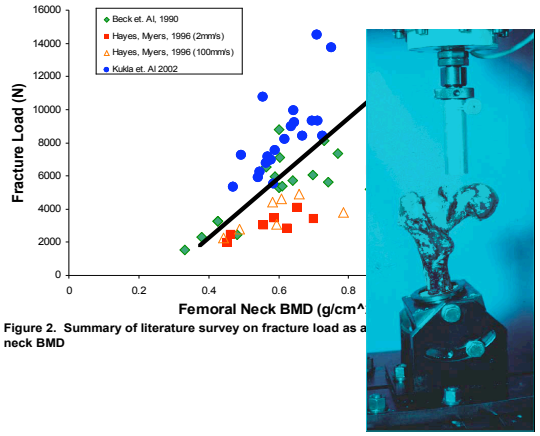


Figure 2. Summary of literature survey on fracture load as a neck BMD

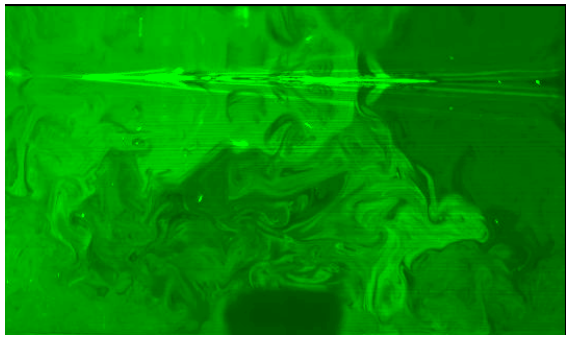
Biomechanics and Loading + **Pre-Flight Health and Bone Loss in Space Flight** + **Characteristics of Bone Strength**

= Estimate of Fracture Probability

- Simulation Model Approach
  - Based on a Monte Carlo sampling of the data space
    - Commercial Simulation Engine: Crystal Ball
    - Integrates best estimate biomedical engineering, clinical and space data
    - Provides for tracking the uncertainty (aletory, epistemic) bounding our output
  - Predicated on estimating a loading event will exceed current bone strength
    - Earth, Moon and Mars Locations

Exploration Medical Capability at GRC

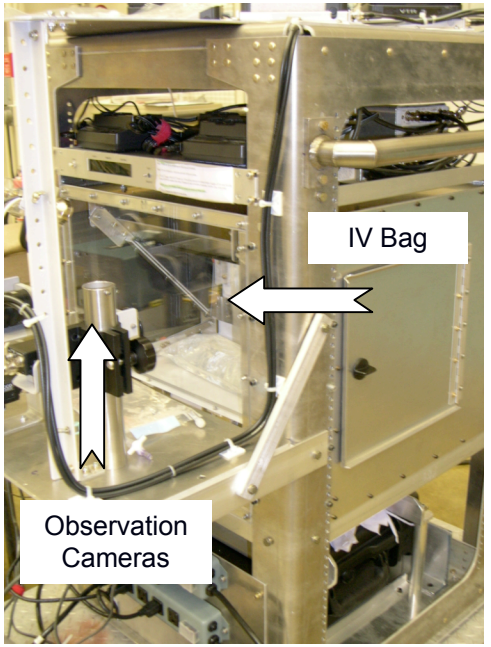
IV Fluid Generation and Drug Mixing



GRC Ground Data :Planar Laser Induced Florescence image of IV Drug Mixing

Rationale:

- Over 100 conditions in the PCDB require an IV
- Rotating stock is impractical for exploration missions
- Mass penalty is too high for a sufficient stock of premixed pharmaceuticals
- Previous NASA microgravity demonstration had incorrect fluid physics



C-9 Rig: IV Fluid Mixing

Accomplishments:

- Completed a white paper analyzing pharmaceutical mixing techniques for hypogravity
- Quantified pharmaceutical mixing in normal and hypogravity
- Completed a white paper analyzing required IV fluid quantities and generation methods
- C-9 test rig to quantify microgravity mixing is complete; First flight week of 23 October

Plans:

- Complete C-9 test campaign to quantify microgravity mixing
- Design, construct and demonstrate in microgravity an IV fluid generation and drug mixing device
- Flight demonstration in FY 2010

Exploration Medical Capability at GRC

In-flight Lab Analysis

Key Focus: Re-Usable Laboratory Analysis Devices

GRC Contributions:

- Analysis of current device applicability
- Paths to develop exploration-compatible devices

Next steps:

- Identify techniques to make lab devices reusable
- Migrate Constellation requirements for medical laboratory analysis to concepts for reusable devices
- Utilize GRC and local partners to fabricate and test prototypes

Strategic Partnerships

- **John Glenn Biomedical Engineering Consortium**
  - Space act agreement with Case Western Reserve University, Cleveland Clinic Foundation, University Hospitals of Cleveland, the National Center for Space Exploration Research to perform interdisciplinary research leveraging GRC expertise in fluid physics and sensor technology to mitigate critical risks to crew health, safety, and performance.
- **Cleveland Clinic Center for Space Medicine**
  - Collaboration via space act agreement to provide an environment and mechanism to promote interdisciplinary research that will exploit the unique skills, capabilities, and facilities of both CCF and NASA GRC in support of long duration spaceflight
  - Congressional appropriation from FY 2006 funds for lecture series and grant seed money
- **BioEnterprise**
  - Space Act Agreement for collaborative efforts to further the development and commercialization of life science related technologies in Northeast Ohio. Allows NASA access to BioEnterprise clients where technologies may be of benefit to NASA's mission.
- **NASA - NIH Interagency Agreement**
  - Technology transfer agreement for a NASA developed ocular device to diagnose vision-related and systemic disorders supporting both NASA's exploration mission and terrestrial medicine.
- **CWRU/University Hospitals**
  - Congressional appropriation from FY 2006 funds applied to studying the effects of cosmic radiation
- **Wright Patterson Air Force Research Laboratory - Human Effectiveness Directorate**
  - Initiating collaborative efforts and identifying potential synergies in research goals and objectives from both NASA and WPAFRL programs. Leveraging off the consolidation of all aerospace medicine and human research activities at WPAFB in response to the BRAC directive.